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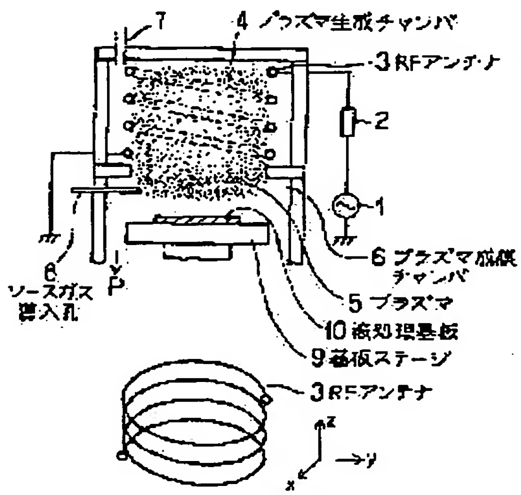
(54) PLASMA CVD DEVICE AND PLASMA CVD METHOD



(57)Abstract:
PURPOSE: To provide the plasma CVD device and method capable of forming even a stable and high-quality conductive thin film of Ti, etc., in the plasma CVD producing plasma with the induction coupling by an RF antenna.
CONSTITUTION: An RF antenna 3 is arranged at the part in contact with the plasma in a plasma producing chamber 4, and an electric field from the antenna 3 is directly impressed on the plasma 5. The surface of the antenna 3 is previously coated with a material contg. an element constituting a film forming material. Since the electric field of the antenna is not transmitted through the dielectric window of the plasma producing chamber unlike the conventional device, a decrease in the electric field strength due to the deposition of a conductive film on the dielectric window is prevented, and treatment is conducted with the constant high-density plasma.

CLAIMS

[Claim(s)]
[Claim 1] Plasma-CVD equipment which is an inductive coupled plasma CVD system possessing RF antenna, a plasma production chamber, a source gas installation hole, and a substrate stage, and is characterized by arranging said RF antenna in the location adjacent to the plasma field in said plasma production chamber.
[Claim 2] RF antenna configuration is plasma-CVD equipment according to claim 1 characterized by being either the shape of a cylindrical coil or the flat-surface coiled forms.
[Claim 3] It is plasma-CVD equipment according to claim 1 characterized by covering with the ingredient of RF antenna with which a front face at least contains the configuration element of a membrane formation ingredient.
[Claim 4] Plasma-CVD equipment according to claim 1 characterized by having the heating means of a plasma membrane formation chamber wall surface.
[Claim 5] A source gas installation hole is plasma-CVD equipment according to claim 1 characterized by arranging between RF antenna and a substrate stage.
[Claim 6] The plasma-CVD approach characterized by forming a thin film on a processed substrate with claim 1 thru/or the plasma-CVD equipment of five given in any 1 term.
[Claim 7] A thin film is the plasma-CVD approach according to claim 6 characterized by being a conductive thin film.
[Claim 8] The plasma-CVD approach according to claim 6 characterized by adding halogen system gas.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the plasma-CVD equipment and the plasma-CVD approach repeatability enables good high membrane formation of a throughput in more detail, about the plasma-CVD equipment and the plasma-CVD approach which are used for production processes, such as a semiconductor device.
[0002]
[Description of the Prior Art] The design rule of semiconductor devices, such as LSI, makes it detailed from a half micron to a quarter micron or the level not more than it, and multilayer-interconnection structure follows on being used abundantly, and the aspect ratio of the connection hole for connecting between wiring layers tends to increase. For example, in the semiconductor device of 0.2-micrometer Ruhr, since there is about 1 micrometer of thickness of an interlayer insulation film to 0.2 micrometers of diameters of opening of a connection hole, an aspect ratio may amount to 5. In order to attain reliable multilayer-interconnection structure, after forming Ti layer for ohmic contacts, and the TiN layer and TiON layer which are the barrier metal which prevents diffusion of a wiring material in a connection hole with this detailed connection hole of a high aspect ratio conformal one, the approach of filling up a connection hole with the upper wiring material or a contact plug is adopted with elevated-temperature sputtering of aluminum system metal, the selection CVD of W, or Blanket CVD.
[0003] Usually, in order to form Ti layer and a TiN layer, sputtering which used Ti metal as the target ingredient, and reactive sputtering are performed. Although

collimation sputtering which raised the vertical-incidence component of a sputtering particle especially attracts attention, it is difficult for an aspect ratio to also form this approach excellent in the step hippo ridge conformal one in the detailed connection hole which amounts also to 5. This problem is explained with reference to drawing 4 and drawing 5 (a) - (d).

[0004] Drawing 4 is the outline sectional view showing the example of 1 configuration of a collimation sputtering system. the target 11 which counters the processed substrate 10 laid in the substrate stage 9, and consists of a Ti metallic material -- arranging -- Ar from a gas installation hole (not shown), and N2 etc. -- after introducing gas and making the inside of the sputtering chamber 13 into a predetermined reduced pressure ambient atmosphere, RF power is impressed between the processed substrate 10 and a target 11. Ti by which the spatter was carried out from the target passes the collimator 12 arranged in the mid-position of the processed substrate 10 and a target 11, and is N2 as a Ti metal as it is. It reacts, is set to TiN and deposits on the processed substrate 10. A collimator 12 is a perforated plate which has the structure in which many through tubes carried out opening to the high numerical aperture in the perpendicular direction to the front face of the processed substrate 10, and is a member which increases the vertical-incidence particle component to a processed substrate and which consists of a ceramics metallurgy group. In addition, in this drawing, details, such as a vacuum pump and a substrate heating device, omit illustration.

[0005] The process which forms Ti layer and a TiN layer on the processed substrate with which the connection hole was formed is explained with reference to drawing 5 (a) - (d) using this collimation sputtering system. first, the semi-conductor substrates 31 top, such as Si in which active elements, such as an impurity diffused layer (not shown), were formed, -- SiO2 etc. -- from -- the interlayer insulation film 32 with a thin thickness of 1 micrometer is formed, and opening of the connection hole 33 of the diameter of 0.2 micrometer which attends an impurity diffused layer is carried out. Let this sample shown in drawing 5 (a) be a processed substrate. Next, it lays on the substrate stage 9 which heated this processed substrate 10 at 200 degrees C, and considers as the condition which 10nm of Ti layers 34 is formed on 25sccm(s), the chamber internal pressure of 0.2Pa, and the sputtering conditions of RF power 8kw, and shows Ar in drawing 5 (b). Next, it is N2. Similarly carried out 25sccm addition, and it introduced, and also is the same sputtering conditions, and 20nm of TiN layers 35 is formed. At this time, as shown in drawing 5 (c), the TiN layer 35 on the connection hole 33 is deposited on an overhang configuration, and the periphery of connection hole 33 pars basilaris ossis occipitalis is formed thinly. If aluminum system metal layer 36 is formed by elevated-temperature sputtering etc. in this condition, as shown in drawing 5 (d), a void 37 may occur, and a problem may arise in the dependability of a contact plug. A void 37 is similarly generated, when adopting CVD of W instead of sputtering of aluminum system metal layer.

[0006] It is TiCl4 in order to solve the problem of the step coverage in these sputtering also including the collimation method. The used plasma CVD is reported to 31 page (1993) a semi-conductor and the 44th time symposium lecture collected works of integrated-circuit technical. TiCl4 This approach of using as material gas is H2. It is [Ti layer by reduction, and] N2 to this gas system further. It is possible to add and to form a TiN layer continuously. High membrane formation of the throughput which could use the high density plasma of whenever [high vacuum / of a 10-1Pa base], and was compatible in the height of step coverage and a membrane formation rate especially according to the ECR plasma CVD system and the

inductively-coupled-plasma CVD system which used RF antenna is possible.
[0007] However, if it was in the inductive coupled plasma CVD system using the conventional RF antenna, conductive film, such as Ti, adhered to the incidence part of the electric field of a plasma production chamber wall, and there was a case where the membrane formation by which effectual RF incidence power was decreased and stabilized became difficult. This problem is explained with reference to drawing 6 and drawing 7 .
[0008] Drawing 6 is the outline sectional view of the plasma-CVD equipment by the conventional ICP (Inductively Coupled Plasma). The side attachment wall of the plasma production chamber 4 is formed by the dielectric-materials aperture 14, and winds this periphery with the RF antenna 3. The dielectric-materials aperture 14 is a member of a cylinder system which consists of a quartz etc. RF power is supplied to the RF antenna 3 through a matching network 2 from the RF power source 1. The plasma gas installation hole 7 is arranged on the plasma production chamber 4 upper part, the material gas of plasma CVD is supplied from here, and the plasma 5 is generated. The plasma membrane formation chamber 6 is connected [lower part / of the plasma production chamber 4], and membranes are formed on the processed substrate 10 laid on the internal substrate stage 9. In addition, in this drawing, details, such as a temperature control means of the substrate stage 9 and a vacuum pump, omit illustration.
[0009] Drawing 7 is the outline sectional view of the plasma-CVD equipment by the conventional TCP (Transformer Coupled Plasma). The top plate of the plasma membrane formation chamber 4 serves as the dielectric-materials aperture 14, and this equipment arranges the spiral RF antenna 3 in contact with this upper part. The dielectric-materials aperture 14 is a disc-like member which consists of a quartz etc. Other configurations other than the above are the same as the plasma-CVD equipment by ICP shown in drawing 6 , and the overlapping explanation is omitted.
[0010] Each plasma-CVD equipment of the two above-mentioned examples approaches the exterior of the plasma production chamber 4, is arranging the RF antenna 3, and has introduced RF electric field in the plasma production chamber 4 through the dielectric-materials aperture 14. For this reason, the decomposition product of gas serves as the adhesion film 15, and it deposits on the interior of the dielectric-materials aperture 14, and when especially this adhesion film 15 is a conductive thin film, a result by which RF electric field are shielded is brought. Therefore, effectual RF incidence power decreased and there was a case where the membrane formation by which a deposition rate and membraneous quality were deteriorated and stabilized became difficult. This was a problem common to the inductively-coupled-plasma CVD system which used not only the plasma-CVD equipment of the two above-mentioned examples but RF antenna.
[0011]
[Problem(s) to be Solved by the Invention] Then, the technical problem of this invention is stable and is offering the inductive coupled plasma CVD system which has RF antenna which enables high membrane formation of repeatability.
[0012] Moreover, the technical problem of this invention is it being stable, and repeatability's being high and offering the good plasma-CVD approach of step coverage moreover using the above-mentioned plasma-CVD equipment. Technical problems other than the above of this invention become clear by explanation of this application specification and an accompanying drawing.
[0013]
[Means for Solving the Problem] The plasma-CVD equipment of this invention is an

inductive coupled plasma CVD system which proposes in order to solve an above-mentioned technical problem, and was equipped with RF antenna, the plasma production chamber, the source gas installation hole, and the substrate stage, and is characterized by arranging RF antenna in the location adjacent to the plasma field in this plasma production chamber.

[0014] RF antenna configuration is the shape of a cylindrical coil, or a flat-surface coiled form, and, moreover, it is [a front face at least] desirable to cover with the ingredient containing the configuration element of a membrane formation ingredient of this RF antenna. For example, what is necessary is just to cover the front face of RF antenna with Ti, in case Ti and TiN are formed.

[0015] Moreover, it is desirable to have the heating means of a plasma membrane formation chamber wall surface. By arranging RF antenna in the interior of a plasma production chamber, it becomes possible to lose especially the limit of the component of a plasma production chamber, and to arrange a resistance heating heater etc. in a plasma membrane formation chamber internal-surface top or Kabeuchi. Metallic materials, quartzes, etc., such as aluminum alloy, can be used for the component of a plasma production chamber.

[0016] furthermore, the thing for which a source gas installation hole is arranged between RF antenna and a substrate stage -- ** -- it is desirable. That is, if it puts in another way, as for the introductory location of deposition nature gas, it is more desirable than RF antenna the downstream and to arrange in the location near [antenna / RF] a vacuum pump.

[0017] The plasma-CVD approach of this invention is proposed in order to solve an above-mentioned technical problem, and it is characterized by forming a thin film on a processed substrate using the above-mentioned plasma-CVD equipment. This plasma-CVD approach uses and is effective for deposition of a conductive thin film, and it is desirable to use the mixed gas which added halogen system gas, such as F system gas, Cl system gas, and Br system gas, further.

[0018]

[Function] The point of the plasma-CVD equipment of this invention is that it arranged RF antenna in the interior of a plasma membrane formation chamber. By this configuration, the electric field of RF antenna are spread to the direct plasma, and the efficient plasma production of it becomes possible. That is, since the electric field of RF antenna are not spread through a dielectric-materials aperture, it does not generate theoretically un-arranging [that a conductive thin film adheres to a dielectric-materials aperture, and electric field are shielded].

[0019] Under the present circumstances, at least, if the front face is covered with the ingredient containing the configuration element of a membrane formation ingredient of RF antenna, even if the spatter of the metaphor RF antenna is carried out, as for the thin film deposited on a processed substrate, cross contamination will not be caused.

[0020] Moreover, by having arranged RF antenna in the interior of a plasma membrane formation chamber, it becomes possible to introduce the heating means of a plasma membrane formation chamber wall surface. When using an organometallic compound for source gas, this can prevent the phenomenon in which the deposit of an organic system adheres to a plasma membrane formation chamber wall, and is effective for reduction of the contamination in a chamber, or particle contamination of a processed substrate.

[0021] Furthermore, since the source gas installation hole of deposition nature was arranged between RF antenna and the substrate stage, there is little possibility that source gas will flow backwards to RF antenna side, and deposition at RF antenna is

controlled. moreover -- even if a thin film accumulates on a metaphor RF antenna -- impedance change of RF antenna -- **** -- it is small and adjustment of a matching network is easy.
[0022] Next, the point of this plasma-CVD approach is that it forms a thin film on a processed substrate using the above-mentioned plasma-CVD equipment. Therefore, it is not influenced by the deposit to a dielectric-materials aperture, but it is stable and plasma-CVD processing that repeatability is high is attained.
[0023] Furthermore, film deposition in RF antenna, a plasma production chamber, etc. is controlled by adding halogen system gas with etching nature to the minimum. Although the plasma-CVD approach of this invention demonstrates the above-mentioned effectiveness regardless of an ingredient, it is used especially for the plasma CVD of a conductive thin film, and is large. [of effectiveness]
[0024]
[Example] Hereafter, with reference to an accompanying drawing, it explains per concrete example of this invention. In addition, in the drawing referred to below, the same reference mark shall be attached about the same part as the component in the drawing referred to by explanation of the conventional technique.
[0025] With the inductive coupled plasma CVD system which used cylindrical-coil-like RF antenna, example 1 this example is an example which formed Ti layer and the TiN layer continuously, and explains this with reference to drawing 1 (a) - (b) and drawing 3 (a) - (d).
[0026] First, with reference to the outline sectional view shown in drawing 1 (a), it explains about the example of a configuration of the plasma-CVD equipment of this example. This equipment arranges the cylindrical-coil-like RF antenna 3 in the location which touches the plasma inside plasma production chamber 4 side face, and supplies RF power to it from the RF power source 1 via a matching network 2. The wall surface of the plasma production chamber 4 is constituted for example, from an aluminum system metal, and it has the heating means (not shown) at a resistance heating heater. The plasma gas installation hole 7 is arranged on the plasma membrane formation chamber 4 upper part, gas and halogen system gas for plasma production are supplied from here, and the plasma 5 is generated. The membrane formation chamber 6 is connected [lower part / of the plasma membrane formation chamber 4], and the processed substrate 10 laid on the substrate stage 9 on the production of the medial axis of the RF antenna 3 is arranged inside. The source gas installation hole 7 is arranged on the middle location of the RF antenna 3 and the substrate stage 9, and the gas of deposition nature is directly introduced into it in the membrane formation chamber 6 from here. In addition, in this drawing, details, such as a temperature control means of the substrate stage 9 and a vacuum pump, omit illustration.
[0027] The RF antenna 3 makes Cu a component for the cylindrical-coil configuration shown in drawing 1 (b) as nothing and an example, and covers the front face with Ti or TiN. In addition, this RF antenna can suppress the temperature up by the ion bombardment, if it considers as a hollow pipe and cools through a refrigerant like water inside. In addition, this RF antenna 3 may have the shape of a cylindrical shape with a taper along that inclined plane, when the taper configuration where plasma production chamber 4 side face inclined is being made. According to RF antenna structure shown in drawing 1 (b), it is possible for it to be uniform and to generate the plasma of high density in rotation of the electron within the field in alignment with plasma production chamber 5 side attachment wall.
[0028] Below, with reference to drawing 3 (a) - (d), it explains about the plasma-CVD

approach of this invention. Since the processed substrate used by this example is the same as that of drawing 5 (a) referred to by explanation of the conventional example, the overlapping explanation is omitted.

[0029] After removing the natural oxidation film on the diffusion layer exposed to connection hole 33 pars basilaris ossis occipitalis of this processed substrate by rare HF water-solution washing, it lays on the substrate stage 9 of the plasma-CVD equipment shown in drawing 1 , and 10nm of Ti layers is deposited according to the following conditions as an example. It is helium from the plasma gas installation hole 7. 100 sccmCl2 30 It is TiCl4 from the sccm source gas installation hole 8. 20 sccmH2 40 sccm gas pressure 0.1 PaRF power-source power 2000 W (13.56MHz) Substrate stage temperature The condition after 450 ** membrane formation is shown in drawing 3 (b). It sets at this plasma-CVD process, and is helium/Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 It dissociates and the Ti layer 34 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. Although the one section of the precursor of Ti system which carried out dissociation generation is diffused in the plasma production chamber 4 and adhered to the wall and the RF antenna 3 of the plasma production chamber 4, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of Ti Having added also contributes to reduction of the amount of Ti adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the Ti layer 34 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible.

[0030] Continuously, TiN is formed in thickness of 20nm according to the following conditions. From the plasma gas installation hole 7, helium 100 sccmCl2 30 From the sccm source gas installation hole 8, TiCl4 20 sccmN2 30 sccmH2 10 sccm gas pressure 0.1 PaRF power-source power 2000 W (13.56MHz)
Substrate stage temperature At a 450 ** book plasma-CVD process, it is helium/Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 And N2 It dissociates and the TiN layer 35 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. The one section of the precursor of the TiN system which carried out dissociation generation is diffused in the plasma production chamber 4, and adheres to the wall and the RF antenna 3 of the plasma production chamber 4. However, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of TiN Having added also contributes to reduction of the amount of TiN adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the TiN layer 35 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible. This condition is shown in drawing 3 (c).

[0031] Next, the processed substrate 10 is conveyed to the sputtering system connected [equipment / this / plasma treatment] through the gate valve, aluminum system metal layer 36 is formed by well-known elevated-temperature sputtering, and the connection hole 33 interior is embedded. Since there was no overhang of the TiN layer 35, aluminum system metal layer 36 was able to be filled up with the inside of the connection hole 33, without generating a void, and, moreover, was able to form the front face evenly. This condition is shown in drawing 3 (d).

[0032] According to this example, by arranging the cylinder-like RF antenna 3 in the

location adjacent to the plasma field in the plasma membrane formation chamber 4, it is a practical deposition rate and it is possible to deposit the conductive thin film excellent in step coverage and membraneous quality.

[0033] With the inductive coupled plasma CVD system using RF antenna of a flat-surface coiled form, example 2 this example is an example which formed Ti layer and the TiN layer continuously, and explains this with reference to drawing 2 (a) - (b) and drawing 3 (a) - (d).

[0034] First, with reference to the outline sectional view shown in drawing 2 (a), it explains about the example of a configuration of the plasma-CVD equipment of this example. This equipment arranges the RF antenna 3 of a flat-surface coiled form in the location which touches the plasma near the top plate of the plasma production chamber 4, and supplies RF power to it from the RF power source 1 via a matching network 2. The top plate and wall surface of the plasma production chamber 4 are constituted for example, from an aluminum system metal, and it has the heating means (not shown) at a resistance heating heater. The plasma gas installation hole 7 is arranged on the plasma production chamber 4 upper part, gas and halogen system gas for plasma production are supplied from here, and the plasma 5 is generated. The membrane formation chamber 6 is connected [lower part / of the plasma membrane formation chamber 4], and the processed substrate 10 laid on the substrate stage 9 on the production of the medial axis of the RF antenna 3 is arranged inside. The source gas installation hole 7 is arranged on the middle location of the RF antenna 3 and the substrate stage 9, and the gas of deposition nature is directly introduced into it in the membrane formation chamber 6 from here. In addition, in this drawing, details, such as a temperature control means of the substrate stage 9 and a vacuum pump, omit illustration.

[0035] The RF antenna 3 makes Cu a component for the configuration shown in drawing 2 (b) as nothing and an example, and covers the front face with Ti compounds, such as Ti or TiN. In drawing 2 R> 2 (b), although the RF antenna 3 is a perfect two-dimensional flat-surface coiled form, in the case of the shape of a dome in which the top plate of the plasma membrane formation chamber 4 had curvature, the three-dimension configuration where this curvature was met may be made. In addition, this RF antenna can suppress the temperature up by the ion bombardment, if it considers as a hollow pipe and cools through a refrigerant like water inside. According to RF antenna structure shown in drawing 2 (b), it is possible for it to be uniform and to generate the plasma of high density in rotation of the electron within the field which met the top plate.

[0036] Below, with reference to drawing 3 (a) - (d), it explains again about the plasma-CVD approach of this invention. Since the processed substrate used by this example is also the same as that of drawing 5 R> 5 (a) referred to by explanation of the conventional example, the overlapping explanation is omitted.

[0037] After removing the natural oxidation film on the diffusion layer exposed to connection hole 33 pars basilaris ossis occipitalis of this processed substrate by rare HF water-solution washing, it lays on the substrate stage 9 of the plasma-CVD equipment shown in drawing 1 , and 10nm of Ti layers is deposited according to the following conditions as an example. Plasma gas installation hole seven H2 20 sccmCl2 30 It is TiCl4 from the sccm source gas installation hole 8. 30 sccm gas pressure 0.5 PaRF power-source power 1500 W (13.56MHz)
Substrate stage temperature The condition after 400 ** membrane formation is shown in drawing 3 (b). It sets at this plasma-CVD process, and they are H2 / Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5

It dissociates and the Ti layer 34 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. Although the one section of the precursor of Ti system which carried out dissociation generation is diffused in the plasma production chamber 4 and adhered to the wall and the RF antenna 3 of the plasma production chamber 4, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of Ti Having added also contributes to reduction of the amount of Ti adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the Ti layer 34 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible.

[0038] Continuously, TiN is formed in thickness of 20nm according to the following conditions. Plasma gas installation hole seven H2 20 sccmCl2 30 It is TiCl4 from the sccm source gas installation hole 8. 30 sccmN2 20 sccm gas pressure 0.5 PaRF power-source power 1500 W (13.56MHz)

Substrate stage temperature At a 400 ** book plasma-CVD process, they are H2 / Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 And N2 It dissociates and the TiN layer 35 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. The one section of the precursor of the TiN system which carried out dissociation generation is diffused in the plasma production chamber 4, and adheres to the wall and the RF antenna 3 of the plasma production chamber 4. However, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of TiN Having added also contributes to reduction of the amount of TiN adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the TiN layer 35 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible. This condition is shown in drawing 3 (c). Since formation of aluminum system metal layer 36 shown in following drawing 3 (d) is the same as a last example, explanation is omitted.

[0039] According to this example, by arranging the plane RF antenna 3 in the location adjacent to the plasma field in the plasma membrane formation chamber 4, it is a practical deposition rate and it is possible to deposit the conductive thin film excellent in step coverage and membraneous quality.

[0040] Conventional ICP equipment or TCP equipment, and a change are not fundamentally except having arranged in the location which also touches the example of two examples mentioned above to plasma 5 field of the plasma production chamber 4 in the arrangement part of the RF antenna 3. Therefore, generating of the high density plasma is possible also for any, and the plasma CVD excellent in a membrane formation rate and homogeneity is possible.

[0041] As mentioned above, although the example of two examples was explained for this invention, this invention is not limited to the above example and various kinds of embodiments are possible for it. For example, you may be equipment which has a cylinder loop-formation-like RF antenna like helicon wave plasma-CVD equipment as plasma-CVD equipment of the inductive-coupling mold which has RF antenna. This equipment arranges the antenna of the shape of two or more loop formation on the periphery of ** RUJA by a quartz etc., it impresses the high frequency of an opposite phase mutually, generates a whistler wave in ** RUJA, conveys energy to an electron through the process of the Landau damping from a whistler wave, accelerates

this, makes a high-speed electron collide with a raw gas molecule, and obtains a high ion current consistency as indicate by the U.S. Pat. No. 5,091,049 specification. A helicon wave is spread along the magnetic field which the solenoid coil installed in the periphery of RF antenna makes.

[0042] Since the electric field which RF antenna makes through ** RUJA of a dielectric also in the case of the above-mentioned helicon wave plasma-CVD equipment were impressed, the deposition by the adhesion film arose in the ** RUJA wall, and there was a case where RF electric field were shielded. Then, this invention is applied, the configuration which arranges a helicon wave antenna in the interior of ** RUJA, then the incidence power of a helicon wave antenna are stabilized, and the plasma-CVD processing excellent in a deposition rate and membraneous quality of them is attained.

[0043] Although Ti and TiN were illustrated as a conductive thin film to deposit, it is possible for TiW, TiON, polycrystalline silicon, etc. to be large in case other metal metallurgy group compounds and a semi-conductor thin film are deposited, and to use. Moreover, it cannot be overemphasized that you may use deposition of an insulating thin film or besides a conductive thin film.

[0044] Although TiCl4 (mp=-25 degree C, bp=136 degree C) was illustrated as source gas of Ti and TiN, the various (mp=39 degree C, bp=230 degree C) halogenation titanium of TiF4 (it sublimates at 284 degrees C), TiBr4, etc. can be used. Moreover, use (tetra-diethylamino titanium) of Ti (N(CH3) 2)4 (tetra-dimethylamino titanium), Ti (N(C two H5) 2)4, etc. is also possible as an organic titanium compound. What is necessary is just to introduce these halogenation titanium and organic Ti compound to plasma-CVD equipment by the well-known burning method or the heating bubbling method using carrier gas. TiCl4 It is a liquid at a room temperature and can use preferably from handling being comparatively simple.

[0045] the source gas of TiN -- on the other hand -- coming out -- as a certain nitrogen system gas -- N2 although illustrated -- NH3 and N two H4 etc. -- the gas which has a nitrogen atom can be used suitably. moreover, the inside of source gas -- further -- O2 NO system gas etc. -- etc. -- also when adding oxygen system gas and forming TiON, the effectiveness of this invention is demonstrated.

[0046] Moreover, a low voltage Hg lamp, excimer laser, a halogen lamp, etc. may apply this invention to the plasma and coincidence at the optical plasma CVD which irradiates an excitation light beam.

[0047]

[Effect of the Invention] It is release **** from the effect of the adhesion film to a plasma production chamber internal surface by having arranged RF antenna of an inductive-coupling mold in the part which touches the plasma field inside a plasma membrane formation chamber according to the plasma-CVD equipment of this invention so that clearly from the above explanation. For this reason, even if it was a conductive thin film, it became possible to offer the plasma-CVD equipment which is stabilized and may generate the high density plasma.

[0048] If the front face of RF antenna is covered with the ingredient containing the configuration element of the membrane formation ingredient to deposit, there will be no fear of the contamination of the processed substrate by the spatter of RF antenna.

[0049] By arranging RF antenna in the interior of a plasma production chamber, it becomes possible to constitute the quality of the material of a plasma production chamber from metallic materials, such as for example, aluminum system metal. For this reason, it becomes possible to add heating means, such as a resistance heating heater, in a plasma production chamber wall surface. Thereby, when using an

organometallic compound as source gas, the phenomenon which an organic affix deposits in a plasma production chamber wall surface can be prevented, and it contributes to reduction of particle contamination.
[0050] furthermore, TiCl4 etc. -- deposition at a plasma production chamber or RF antenna decreases by arranging the source gas installation hole directly contributed to deposition between RF antenna and a substrate stage.
[0051] Moreover, according to the plasma-CVD approach of this invention, even if it is formation of conductive thin films, such as Ti and TiN, it is possible for it to be stabilized and to form the thin film using the high density plasma the deposition rate excelled [thin film] in membraneous quality highly with sufficient repeatability.
[0052] Moreover, in the reactant gas in plasma CVD, if the halogen system gas used as the etching gas of a formation ingredient is added, film adhesion in RF antenna or a plasma production chamber internal surface can be reduced further, and particle contamination can be reduced.
[0053] It is size the place which this invention contributes to the manufacture process of a semiconductor device of having a multilayer interconnection based on the detailed design rule of a deep submicron class, according to the above-mentioned effectiveness, and the utility value on the industry of this invention is high.

TECHNICAL FIELD

[Industrial Application] This invention relates to the plasma-CVD equipment and the plasma-CVD approach repeatability enables good high membrane formation of a throughput in more detail, about the plasma-CVD equipment and the plasma-CVD approach which are used for production processes, such as a semiconductor device.

PRIOR ART

[Description of the Prior Art] The design rule of semiconductor devices, such as LSI, makes it detailed from a half micron to a quarter micron or the level not more than it, and multilayer-interconnection structure follows on being used abundantly, and the aspect ratio of the connection hole for connecting between wiring layers tends to increase. For example, in the semiconductor device of 0.2-micrometer Ruhr, since there is about 1 micrometer of thickness of an interlayer insulation film to 0.2 micrometers of diameters of opening of a connection hole, an aspect ratio may amount to 5. In order to attain reliable multilayer-interconnection structure, after forming Ti layer for ohmic contacts, and the TiN layer and TiON layer which are the barrier metal which prevents diffusion of a wiring material in a connection hole with this detailed connection hole of a high aspect ratio conformal one, the approach of filling up a connection hole with the upper wiring material or a contact plug is adopted with elevated-temperature sputtering of aluminum system metal, the selection CVD of W, or Blanket CVD.
[0003] Usually, in order to form Ti layer and a TiN layer, sputtering which used Ti metal as the target ingredient, and reactive sputtering are performed. Although collimation sputtering which raised the vertical-incidence component of a sputtering particle especially attracts attention, it is difficult for an aspect ratio to also form this approach excellent in the step hippo ridge conformal one in the detailed connection hole which amounts also to 5. This problem is explained with reference to drawing 4

and drawing 5 (a) - (d).

[0004] Drawing 4 is the outline sectional view showing the example of 1 configuration of a collimation sputtering system. the target 11 which counters the processed substrate 10 laid in the substrate stage 9, and consists of a Ti metallic material -- arranging -- Ar from a gas installation hole (not shown), and N2 etc. -- after introducing gas and making the inside of the sputtering chamber 13 into a predetermined reduced pressure ambient atmosphere, RF power is impressed between the processed substrate 10 and a target 11. Ti by which the spatter was carried out from the target passes the collimator 12 arranged in the mid-position of the processed substrate 10 and a target 11, and is N2 as a Ti metal as it is. It reacts, is set to TiN and deposits on the processed substrate 10. A collimator 12 is a perforated plate which has the structure in which many through tubes carried out opening to the high numerical aperture in the perpendicular direction to the front face of the processed substrate 10, and is a member which increases the vertical-incidence particle component to a processed substrate and which consists of a ceramics metallurgy group. In addition, in this drawing, details, such as a vacuum pump and a substrate heating device, omit illustration.

[0005] The process which forms Ti layer and a TiN layer on the processed substrate with which the connection hole was formed is explained with reference to drawing 5 (a) - (d) using this collimation sputtering system. first, the semi-conductor substrates 31 top, such as Si in which active elements, such as an impurity diffused layer (not shown), were formed, -- SiO2 etc. -- from -- the interlayer insulation film 32 with a thin thickness of 1 micrometer is formed, and opening of the connection hole 33 of the diameter of 0.2 micrometer which attends an impurity diffused layer is carried out. Let this sample shown in drawing 5 (a) be a processed substrate. Next, it lays on the substrate stage 9 which heated this processed substrate 10 at 200 degrees C, and considers as the condition which 10nm of Ti layers 34 is formed on 25sccm(s), the chamber internal pressure of 0.2Pa, and the sputtering conditions of RF power 8kw, and shows Ar in drawing 5 (b). Next, it is N2. Similarly carried out 25sccm addition, and it introduced, and also is the same sputtering conditions, and 20nm of TiN layers 35 is formed. At this time, as shown in drawing 5 (c), the TiN layer 35 on the connection hole 33 is deposited on an overhang configuration, and the periphery of connection hole 33 pars basilaris ossis occipitalis is formed thinly. If aluminum system metal layer 36 is formed by elevated-temperature sputtering etc. in this condition, as shown in drawing 5 (d), a void 37 may occur, and a problem may arise in the dependability of a contact plug. A void 37 is similarly generated, when adopting CVD of W instead of sputtering of aluminum system metal layer.

[0006] It is TiCl4 in order to solve the problem of the step coverage in these sputtering also including the collimation method. The used plasma CVD is reported to 31 page (1993) a semi-conductor and the 44th time symposium lecture collected works of integrated-circuit technical. TiCl4 This approach of using as material gas is H2. It is [Ti layer by reduction, and] N2 to this gas system further. It is possible to add and to form a TiN layer continuously. High membrane formation of the throughput which could use the high density plasma of whenever [high vacuum / of a 10-1Pa base], and was compatible in the height of step coverage and a membrane formation rate especially according to the ECR plasma CVD system and the inductively-coupled-plasma CVD system which used RF antenna is possible.

[0007] However, if it was in the inductive coupled plasma CVD system using the conventional RF antenna, conductive film, such as Ti, adhered to the incidence part of the electric field of a plasma production chamber wall, and there was a case where the

membrane formation by which effectual RF incidence power was decreased and stabilized became difficult. This problem is explained with reference to drawing 6 and drawing 7 .

[0008] Drawing 6 is the outline sectional view of the plasma-CVD equipment by the conventional ICP (Inductively Coupled Plasma). The side attachment wall of the plasma production chamber 4 is formed by the dielectric-materials aperture 14, and winds this periphery with the RF antenna 3. The dielectric-materials aperture 14 is a member of a cylinder system which consists of a quartz etc. RF power is supplied to the RF antenna 3 through a matching network 2 from the RF power source 1. The plasma gas installation hole 7 is arranged on the plasma production chamber 4 upper part, the material gas of plasma CVD is supplied from here, and the plasma 5 is generated. The plasma membrane formation chamber 6 is connected [lower part / of the plasma production chamber 4], and membranes are formed on the processed substrate 10 laid on the internal substrate stage 9. In addition, in this drawing, details, such as a temperature control means of the substrate stage 9 and a vacuum pump, omit illustration.

[0009] Drawing 7 is the outline sectional view of the plasma-CVD equipment by the conventional TCP (Transformer Coupled Plasma). The top plate of the plasma membrane formation chamber 4 serves as the dielectric-materials aperture 14, and this equipment arranges the spiral RF antenna 3 in contact with this upper part. The dielectric-materials aperture 14 is a disc-like member which consists of a quartz etc. Other configurations other than the above are the same as the plasma-CVD equipment by ICP shown in drawing 6 , and the overlapping explanation is omitted.

[0010] Each plasma-CVD equipment of the two above-mentioned examples approaches the exterior of the plasma production chamber 4, is arranging the RF antenna 3, and has introduced RF electric field in the plasma production chamber 4 through the dielectric-materials aperture 14. For this reason, the decomposition product of gas serves as the adhesion film 15, and it deposits on the interior of the dielectric-materials aperture 14, and when especially this adhesion film 15 is a conductive thin film, a result by which RF electric field are shielded is brought. Therefore, effectual RF incidence power decreased and there was a case where the membrane formation by which a deposition rate and membraneous quality were deteriorated and stabilized became difficult. This was a problem common to the inductively-coupled-plasma CVD system which used not only the plasma-CVD equipment of the two above-mentioned examples but RF antenna.

EFFECT OF THE INVENTION

[Effect of the Invention] It is release **** from the effect of the adhesion film to a plasma production chamber internal surface by having arranged RF antenna of an inductive-coupling mold in the part which touches the plasma field inside a plasma membrane formation chamber according to the plasma-CVD equipment of this invention so that clearly from the above explanation. For this reason, even if it was a conductive thin film, it became possible to offer the plasma-CVD equipment which is stabilized and may generate the high density plasma.

[0048] If the front face of RF antenna is covered with the ingredient containing the configuration element of the membrane formation ingredient to deposit, there will be no fear of the contamination of the processed substrate by the spatter of RF antenna.

[0049] By arranging RF antenna in the interior of a plasma production chamber, it

becomes possible to constitute the quality of the material of a plasma production chamber from metallic materials, such as for example, aluminum system metal. For this reason, it becomes possible to add heating means, such as a resistance heating heater, in a plasma production chamber wall surface. Thereby, when using an organometallic compound as source gas, the phenomenon which an organic affix deposits in a plasma production chamber wall surface can be prevented, and it contributes to reduction of particle contamination.
[0050] furthermore, $TiCl_4$ etc. -- deposition at a plasma production chamber or RF antenna decreases by arranging the source gas installation hole directly contributed to deposition between RF antenna and a substrate stage.
[0051] Moreover, according to the plasma-CVD approach of this invention, even if it is formation of conductive thin films, such as Ti and TiN, it is possible for it to be stabilized and to form the thin film using the high density plasma the deposition rate excelled [thin film] in membraneous quality highly with sufficient repeatability.
[0052] Moreover, in the reactant gas in plasma CVD, if the halogen system gas used as the etching gas of a formation ingredient is added, film adhesion in RF antenna or a plasma production chamber internal surface can be reduced further, and particle contamination can be reduced.
[0053] It is size the place which this invention contributes to the manufacture process of a semiconductor device of having a multilayer interconnection based on the detailed design rule of a deep submicron class, according to the above-mentioned effectiveness, and the utility value on the industry of this invention is high.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Then, the technical problem of this invention is stable and is offering the inductive coupled plasma CVD system which has RF antenna which enables high membrane formation of repeatability.
[0012] Moreover, the technical problem of this invention is it being stable, and repeatability's being high and offering the good plasma-CVD approach of step coverage moreover using the above-mentioned plasma-CVD equipment. Technical problems other than the above of this invention become clear by explanation of this application specification and an accompanying drawing.

MEANS

[Means for Solving the Problem] The plasma-CVD equipment of this invention is an inductive coupled plasma CVD system which proposes in order to solve an above-mentioned technical problem, and was equipped with RF antenna, the plasma production chamber, the source gas installation hole, and the substrate stage, and is characterized by arranging RF antenna in the location adjacent to the plasma field in this plasma production chamber.
[0014] RF antenna configuration is the shape of a cylindrical coil, or a flat-surface coiled form, and, moreover, it is [a front face at least] desirable to cover with the ingredient containing the configuration element of a membrane formation ingredient of this RF antenna. For example, what is necessary is just to cover the front face of RF antenna with Ti, in case Ti and TiN are formed.
[0015] Moreover, it is desirable to have the heating means of a plasma membrane

formation chamber wall surface. By arranging RF antenna in the interior of a plasma production chamber, it becomes possible to lose especially the limit of the component of a plasma production chamber, and to arrange a resistance heating heater etc. in a plasma membrane formation chamber internal-surface top or Kabeuchi. Metallic materials, quartzes, etc., such as aluminum alloy, can be used for the component of a plasma production chamber.

[0016] furthermore, the thing for which a source gas installation hole is arranged between RF antenna and a substrate stage -- ** -- it is desirable. That is, if it puts in another way, as for the introductory location of deposition nature gas, it is more desirable than RF antenna the downstream and to arrange in the location near [antenna / RF] a vacuum pump.

[0017] The plasma-CVD approach of this invention is proposed in order to solve an above-mentioned technical problem, and it is characterized by forming a thin film on a processed substrate using the above-mentioned plasma-CVD equipment. This plasma-CVD approach uses and is effective for deposition of a conductive thin film, and it is desirable to use the mixed gas which added halogen system gas, such as F system gas, Cl system gas, and Br system gas, further.

OPERATION

[Function] The point of the plasma-CVD equipment of this invention is that it arranged RF antenna in the interior of a plasma membrane formation chamber. By this configuration, the electric field of RF antenna are spread to the direct plasma, and the efficient plasma production of it becomes possible. That is, since the electric field of RF antenna are not spread through a dielectric-materials aperture, it does not generate theoretically un-arranging [that a conductive thin film adheres to a dielectric-materials aperture, and electric field are shielded].

[0019] Under the present circumstances, at least, if the front face is covered with the ingredient containing the configuration element of a membrane formation ingredient of RF antenna, even if the spatter of the metaphor RF antenna is carried out, as for the thin film deposited on a processed substrate, cross contamination will not be caused.

[0020] Moreover, by having arranged RF antenna in the interior of a plasma membrane formation chamber, it becomes possible to introduce the heating means of a plasma membrane formation chamber wall surface. When using an organometallic compound for source gas, this can prevent the phenomenon in which the deposit of an organic system adheres to a plasma membrane formation chamber wall, and is effective for reduction of the contamination in a chamber, or particle contamination of a processed substrate.

[0021] Furthermore, since the source gas installation hole of deposition nature was arranged between RF antenna and the substrate stage, there is little possibility that source gas will flow backwards to RF antenna side, and deposition at RF antenna is controlled. moreover -- even if a thin film accumulates on a metaphor RF antenna -- impedance change of RF antenna -- **** -- it is small and adjustment of a matching network is easy.

[0022] Next, the point of this plasma-CVD approach is that it forms a thin film on a processed substrate using the above-mentioned plasma-CVD equipment. Therefore, it is not influenced by the deposit to a dielectric-materials aperture, but it is stable and plasma-CVD processing that repeatability is high is attained.

[0023] Furthermore, film deposition in RF antenna, a plasma production chamber, etc.

is controlled by adding halogen system gas with etching nature to the minimum. Although the plasma-CVD approach of this invention demonstrates the above-mentioned effectiveness regardless of an ingredient, it is used especially for the plasma CVD of a conductive thin film, and is large. [of effectiveness]

EXAMPLE

[Example] Hereafter, with reference to an accompanying drawing, it explains per concrete example of this invention. In addition, in the drawing referred to below, the same reference mark shall be attached about the same part as the component in the drawing referred to by explanation of the conventional technique.

[0025] With the inductive coupled plasma CVD system which used cylindrical-coil-like RF antenna, example 1 this example is an example which formed Ti layer and the TiN layer continuously, and explains this with reference to drawing 1 (a) - (b) and drawing 3 (a) - (d).

[0026] First, with reference to the outline sectional view shown in drawing 1 (a), it explains about the example of a configuration of the plasma-CVD equipment of this example. This equipment arranges the cylindrical-coil-like RF antenna 3 in the location which touches the plasma inside plasma production chamber 4 side face, and supplies RF power to it from the RF power source 1 via a matching network 2. The wall surface of the plasma production chamber 4 is constituted for example, from an aluminum system metal, and it has the heating means (not shown) at a resistance heating heater. The plasma gas installation hole 7 is arranged on the plasma membrane formation chamber 4 upper part, gas and halogen system gas for plasma production are supplied from here, and the plasma 5 is generated. The membrane formation chamber 6 is connected [lower part / of the plasma membrane formation chamber 4], and the processed substrate 10 laid on the substrate stage 9 on the production of the medial axis of the RF antenna 3 is arranged inside. The source gas installation hole 7 is arranged on the middle location of the RF antenna 3 and the substrate stage 9, and the gas of deposition nature is directly introduced into it in the membrane formation chamber 6 from here. In addition, in this drawing, details, such as a temperature control means of the substrate stage 9 and a vacuum pump, omit illustration.

[0027] The RF antenna 3 makes Cu a component for the cylindrical-coil configuration shown in drawing 1 (b) as nothing and an example, and covers the front face with Ti or TiN. In addition, this RF antenna can suppress the temperature up by the ion bombardment, if it considers as a hollow pipe and cools through a refrigerant like water inside. In addition, this RF antenna 3 may have the shape of a cylindrical shape with a taper along that inclined plane, when the taper configuration where plasma production chamber 4 side face inclined is being made. According to RF antenna structure shown in drawing 1 (b), it is possible for it to be uniform and to generate the plasma of high density in rotation of the electron within the field in alignment with plasma production chamber 5 side attachment wall.

[0028] Below, with reference to drawing 3 (a) - (d), it explains about the plasma-CVD approach of this invention. Since the processed substrate used by this example is the same as that of drawing 5 (a) referred to by explanation of the conventional example, the overlapping explanation is omitted.

[0029] After removing the natural oxidation film on the diffusion layer exposed to connection hole 33 pars basilaris ossis occipitalis of this processed substrate by rare

HF water-solution washing, it lays on the substrate stage 9 of the plasma-CVD equipment shown in drawing 1 , and 10nm of Ti layers is deposited according to the following conditions as an example. It is helium from the plasma gas installation hole 7. 100 sccmCl2 30 It is TiCl4 from the sccm source gas installation hole 8. 20 sccmH2 40 sccm gas pressure 0.1 PaRF power-source power 2000 W (13.56MHz) Substrate stage temperature The condition after 450 ** membrane formation is shown in drawing 3 (b). It sets at this plasma-CVD process, and is helium/Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 It dissociates and the Ti layer 34 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. Although the one section of the precursor of Ti system which carried out dissociation generation is diffused in the plasma production chamber 4 and adhered to the wall and the RF antenna 3 of the plasma production chamber 4, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of Ti Having added also contributes to reduction of the amount of Ti adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the Ti layer 34 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible.

[0030] Continuously, TiN is formed in thickness of 20nm according to the following conditions. From the plasma gas installation hole 7, helium 100 sccmCl2 30 From the sccm source gas installation hole 8, TiCl4 20 sccmN2 30 sccmH2 10 sccm gas pressure 0.1 PaRF power-source power 2000 W (13.56MHz)
Substrate stage temperature At a 450 ** book plasma-CVD process, it is helium/Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 And N2 It dissociates and the TiN layer 35 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. The one section of the precursor of the TiN system which carried out dissociation generation is diffused in the plasma production chamber 4, and adheres to the wall and the RF antenna 3 of the plasma production chamber 4. However, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of TiN Having added also contributes to reduction of the amount of TiN adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the TiN layer 35 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible. This condition is shown in drawing 3 (c).

[0031] Next, the processed substrate 10 is conveyed to the sputtering system connected [equipment / this / plasma treatment] through the gate valve, aluminum system metal layer 36 is formed by well-known elevated-temperature sputtering, and the connection hole 33 interior is embedded. Since there was no overhang of the TiN layer 35, aluminum system metal layer 36 was able to be filled up with the inside of the connection hole 33, without generating a void, and, moreover, was able to form the front face evenly. This condition is shown in drawing 3 (d).

[0032] According to this example, by arranging the cylinder-like RF antenna 3 in the location adjacent to the plasma field in the plasma membrane formation chamber 4, it is a practical deposition rate and it is possible to deposit the conductive thin film excellent in step coverage and membraneous quality.

[0033] With the inductive coupled plasma CVD system using RF antenna of a flat-surface coiled form, example 2 this example is an example which formed Ti layer and

the TiN layer continuously, and explains this with reference to drawing 2 (a) - (b) and drawing 3 (a) - (d).

[0034] First, with reference to the outline sectional view shown in drawing 2 (a), it explains about the example of a configuration of the plasma-CVD equipment of this example. This equipment arranges the RF antenna 3 of a flat-surface coiled form in the location which touches the plasma near the top plate of the plasma production chamber 4, and supplies RF power to it from the RF power source 1 via a matching network 2. The top plate and wall surface of the plasma production chamber 4 are constituted for example, from an aluminum system metal, and it has the heating means (not shown) at a resistance heating heater. The plasma gas installation hole 7 is arranged on the plasma production chamber 4 upper part, gas and halogen system gas for plasma production are supplied from here, and the plasma 5 is generated. The membrane formation chamber 6 is connected [lower part / of the plasma membrane formation chamber 4], and the processed substrate 10 laid on the substrate stage 9 on the production of the medial axis of the RF antenna 3 is arranged inside. The source gas installation hole 7 is arranged on the middle location of the RF antenna 3 and the substrate stage 9, and the gas of deposition nature is directly introduced into it in the membrane formation chamber 6 from here. In addition, in this drawing, details, such as a temperature control means of the substrate stage 9 and a vacuum pump, omit illustration.

[0035] The RF antenna 3 makes Cu a component for the configuration shown in drawing 2 (b) as nothing and an example, and covers the front face with Ti compounds, such as Ti or TiN. In drawing 2 R> 2 (b), although the RF antenna 3 is a perfect two-dimensional flat-surface coiled form, in the case of the shape of a dome in which the top plate of the plasma membrane formation chamber 4 had curvature, the three-dimension configuration where this curvature was met may be made. In addition, this RF antenna can suppress the temperature up by the ion bombardment, if it considers as a hollow pipe and cools through a refrigerant like water inside. According to RF antenna structure shown in drawing 2 (b), it is possible for it to be uniform and to generate the plasma of high density in rotation of the electron within the field which met the top plate.

[0036] Below, with reference to drawing 3 (a) - (d), it explains again about the plasma-CVD approach of this invention. Since the processed substrate used by this example is also the same as that of drawing 5 R> 5 (a) referred to by explanation of the conventional example, the overlapping explanation is omitted.

[0037] After removing the natural oxidation film on the diffusion layer exposed to connection hole 33 pars basilaris ossis occipitalis of this processed substrate by rare HF water-solution washing, it lays on the substrate stage 9 of the plasma-CVD equipment shown in drawing 1 , and 10nm of Ti layers is deposited according to the following conditions as an example. Plasma gas installation hole seven H2 20 sccmCl2 30 It is TiCl4 from the sccm source gas installation hole 8. 30 sccm gas pressure 0.5 PaRF power-source power 1500 W (13.56MHz)
Substrate stage temperature The condition after 400 ** membrane formation is shown in drawing 3 (b). It sets at this plasma-CVD process, and they are H2 / Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 It dissociates and the Ti layer 34 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. Although the one section of the precursor of Ti system which carried out dissociation generation is diffused in the plasma production chamber 4 and adhered to the wall and the RF antenna 3 of the plasma production chamber 4, this coating weight is slight, and the RF antenna 3 is in contact

with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of Ti Having added also contributes to reduction of the amount of Ti adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the Ti layer 34 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible.

[0038] Continuously, TiN is formed in thickness of 20nm according to the following conditions. Plasma gas installation hole seven H2 20 sccmCl2 30 It is TiCl4 from the sccm source gas installation hole 8. 30 sccmN2 20 sccm gas pressure 0.5 PaRF power-source power 1500 W (13.56MHz)

Substrate stage temperature At a 400 ** book plasma-CVD process, they are H2 / Cl2. TiCl4 which the plasma 5 by mixed gas generates and serves as source gas by this plasma 5 And N2 It dissociates and the TiN layer 35 is formed on the processed substrate 10 located in the lower stream of a river of a gas flow. The one section of the precursor of the TiN system which carried out dissociation generation is diffused in the plasma production chamber 4, and adheres to the wall and the RF antenna 3 of the plasma production chamber 4. However, this coating weight is slight, and the RF antenna 3 is in contact with plasma 5 field, and since it is not association through a dielectric-materials aperture, the incidence power of RF does not decline. Cl2 which is the etching gas of TiN Having added also contributes to reduction of the amount of TiN adhering to the wall and the RF antenna 3 of the plasma production chamber 4. Therefore, membrane formation of the TiN layer 35 which whose membraneous quality is good and does not have overhanging at the stable deposition rate is possible. This condition is shown in drawing 3 (c). Since formation of aluminum system metal layer 36 shown in following drawing 3 (d) is the same as a last example, explanation is omitted.

[0039] According to this example, by arranging the plane RF antenna 3 in the location adjacent to the plasma field in the plasma membrane formation chamber 4, it is a practical deposition rate and it is possible to deposit the conductive thin film excellent in step coverage and membraneous quality.

[0040] Conventional ICP equipment or TCP equipment, and a change are not fundamentally except having arranged in the location which also touches the example of two examples mentioned above to plasma 5 field of the plasma production chamber 4 in the arrangement part of the RF antenna 3. Therefore, generating of the high density plasma is possible also for any, and the plasma CVD excellent in a membrane formation rate and homogeneity is possible.

[0041] As mentioned above, although the example of two examples was explained for this invention, this invention is not limited to the above example and various kinds of embodiments are possible for it. For example, you may be equipment which has a cylinder loop-formation-like RF antenna like helicon wave plasma-CVD equipment as plasma-CVD equipment of the inductive-coupling mold which has RF antenna. This equipment arranges the antenna of the shape of two or more loop formation on the periphery of ** RUJA by a quartz etc., it impresses the high frequency of an opposite phase mutually, generates a whistler wave in ** RUJA, conveys energy to an electron through the process of the Landau damping from a whistler wave, accelerates this, makes a high-speed electron collide with a raw gas molecule, and obtains a high ion current consistency as indicate by the U.S. Pat. No. 5,091,049 specification. A helicon wave is spread along the magnetic field which the solenoid coil installed in the periphery of RF antenna makes.

[0042] Since the electric field which RF antenna makes through ** RUJA of a

dielectric also in the case of the above-mentioned helicon wave plasma-CVD equipment were impressed, the deposition by the adhesion film arose in the ** RUJA wall, and there was a case where RF electric field were shielded. Then, this invention is applied, the configuration which arranges a helicon wave antenna in the interior of ** RUJA, then the incidence power of a helicon wave antenna are stabilized, and the plasma-CVD processing excellent in a deposition rate and membraneous quality of them is attained.

[0043] Although Ti and TiN were illustrated as a conductive thin film to deposit, it is possible for TiW, TiON, polycrystalline silicon, etc. to be large in case other metal metallurgy group compounds and a semi-conductor thin film are deposited, and to use. Moreover, it cannot be overemphasized that you may use deposition of an insulating thin film or besides a conductive thin film.

[0044] Although TiCl4 (mp=-25 degree C, bp=136 degree C) was illustrated as source gas of Ti and TiN, the various (mp=39 degree C, bp=230 degree C) halogenation titanium of TiF4 (it sublimates at 284 degrees C), TiBr4, etc. can be used. Moreover, use (tetra-diethylamino titanium) of Ti (N(CH3) 2)4 (tetra-dimethylamino titanium), Ti (N(C two H5) 2)4, etc. is also possible as an organic titanium compound. What is necessary is just to introduce these halogenation titanium and organic Ti compound to plasma-CVD equipment by the well-known burning method or the heating bubbling method using carrier gas. TiCl4 It is a liquid at a room temperature and can use preferably from handling being comparatively simple.

[0045] the source gas of TiN -- on the other hand -- coming out -- as a certain nitrogen system gas -- N2 although illustrated -- NH3 and N two H4 etc. -- the gas which has a nitrogen atom can be used suitably. moreover, the inside of source gas -- further -- O2 NO system gas etc. -- etc. -- also when adding oxygen system gas and forming TiON, the effectiveness of this invention is demonstrated.

[0046] Moreover, a low voltage Hg lamp, excimer laser, a halogen lamp, etc. may apply this invention to the plasma and coincidence at the optical plasma CVD which irradiates an excitation light beam.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the drawing with which explanation of the plasma-CVD equipment of the example 1 which applied this invention is presented, and is the perspective view in which (a) shows the outline sectional view of plasma-CVD equipment, and (b) shows the configuration of RF antenna.

[Drawing 2] It is the drawing with which explanation of the plasma-CVD equipment of the example 2 which applied this invention is presented, and is the perspective view in which (a) shows the outline sectional view of plasma-CVD equipment, and (b) shows the configuration of RF antenna.

[Drawing 3] It is the drawing in which the plasma-CVD approach of the examples 1 and 2 which applied this invention is shown in order of the process, and the condition to which (a) carried out opening of the connection hole to the interlayer insulation film on a semi-conductor substrate, the condition in which (b) formed Ti layer, the condition in which (c) formed the TiN layer further, and (d) are in the condition in which aluminum system metal layer was formed.

[Drawing 4] It is the outline sectional view with which explanation of the conventional example is presented and in which showing the example of 1

configuration of a collimation sputtering system.
[Drawing 5] It is the outline sectional view which explains the trouble of the conventional example in order of the process, and is in the condition to which (a) carried out opening of the connection hole to the interlayer insulation film on a semi-conductor substrate, the condition in which (b) formed Ti layer, the condition in which (c) formed the TiN layer, and the condition which (d) formed aluminum system metal layer and the void generated.
[Drawing 6] It is the outline sectional view showing the plasma-CVD equipment by ICP of the conventional example.
[Drawing 7] It is the outline sectional view showing the plasma-CVD equipment by TCP of the conventional example.
[Description of Notations]
1 RF Power Source
2 Matching Network
3 RF Antenna
4 Plasma Production Chamber
5 Plasma
6 Plasma Membrane Formation Chamber
7 Plasma Gas Installation Hole
8 Source Gas Installation Hole
9 Substrate Stage
10 Processed Substrate
11 Target
12 Collimator
13 Sputtering Chamber
14 Dielectric-Materials Aperture
15 Adhesion Film
31 Semi-conductor Substrate
32 Interlayer Insulation Film
33 Connection Hole
34 Ti Layer
35 TiN Layer
36 Aluminum System Metal Layer
37 Void